



## New Product

# New 3500/45 Position Monitor can be a thrust, differential expansion or case expansion monitor

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**T**he 3500/45 Position Monitor now provides inputs for three critical position parameters: thrust, differential expansion, and case expansion. These three parameters provide an accurate picture of the axial position condition of your steam turbine.

The rotor and case of large steam turbines grow at different rates during start-up, shutdown, and load changes. Monitoring this growth is necessary, as rotating parts can contact stationary parts of the steam turbine, causing substantial machine damage. Typically, case expansion and differential expansion are used to monitor this growth.

### Differential expansion

Differential expansion measurements compare the growth of the rotor relative to the case. As the machine heats, the rotor may expand faster than the case, or the case may expand faster than the rotor, depending upon the rotor-to-case mass ratio. For example, if the rotor has less mass than the case, it will expand faster than the case. By measuring rotor growth relative to the case, limits can be set to indicate when the turbine must be stabilized (heat soaked). This allows the differential growth between the case and rotor to decrease before increasing the temperature.

### Case expansion

Case expansion is a measurement of machine case growth relative to its founda-

tion. During the startup of a steam turbine, case growth is expected. Abnormal case growth occurs when a case foot becomes stuck, which can cause the case to expand unevenly. A stuck foot tends to misalign the rotor and increase case stress which can lead to a rub or excessive vibration.

A case expansion monitor protects a turbine from damage from abnormal case growth by warning an operator when one side of the case grows more than the other. In an ideal application of case expansion monitoring, two linear variable differential transformers (LVDTs) are used, one on each side of the case. Alarms can be set, based on predefined differences between the two LVDT measurements. This will warn the operator that the case foot is stuck and must be corrected. The operator will typically inspect the foundation, make sure it is properly greased, and ensure no foreign objects are in the expansion slots prior to using a jack or hammer to free the case foot, so the case can move freely.

### 3500/45 Position Monitor

The 3500/45 Position Monitor is an enhancement to the original 3500/45 Differential Expansion/Thrust Monitor. It incorporates the case expansion measurement. This four channel monitor is easy to set up, using our 3500 Configuration Software. Since one monitor can serve as a spare for different monitor types, spare parts costs can be reduced. Any channel in a 3500/45 can be configured to monitor thrust position or differential expansion. Several differ-



ent types of differential expansion measurements are supported including:

- Standard Differential Expansion
- Complementary Input Differential Expansion (CIDE)
- Standard Single Ramp Differential Expansion
- Nonstandard Single Ramp Differential Expansion
- Dual Ramp Differential Expansion

The differential expansion and thrust channels of the Position Monitor will accept signal inputs from the following Bently Nevada transducers:

- 5, 8, 11, and 14 mm 7200 Systems
- 8 mm 3300 System
- 25, 35, and 50 mm Extended Range Systems
- 50 mm Differential Expansion Transducer
- 3300 RAM System
- 3000 Series System

The Position Monitor can be configured for case expansion measurement on Channels 3 and 4 and will accept signal inputs from the existing Bently Nevada 24765 Case Expansion Transducer. Bently Nevada will soon manufacture a new High Temperature Case Expansion Transducer, which will have CE approval, an improved operating temperature of 85°C (185°F), and will be compatible with the Position Monitor.

The Position Monitor provides system flexibility and optimum channel utilization. Differential expansion measurements can be made on Channels 1 and 2 and case expansion measurements on Channels 3 and 4. If the turbine requires more than two channels of differential expansion measurements, Channels 3 and 4 can also be used for differential expansion, and the case expansion measurements can be moved to another Position Monitor. Any channels not used for differential expansion or case expansion can be configured for thrust measurements.

The 3500/45 Position Monitor is a component of Bently Nevada's new 3500 Machinery Data Management System. Contact your nearest sales representative for more information. ■



## Famous names in rotor dynamics

### William Rankine introduced much of the terminology and notation of thermodynamics still in use today



**W**illiam J. Macquorn Rankine ('rang kin), 1820-1872, a "Renaissance" man dedicated to translating theoretical principles into practical terms in the Steam Age, may have also been responsible for setting back the science of rotor dynamics by nearly fifty years.

Rankine was born in Edinburgh, Scotland. He was the son of an army lieutenant and received his early schooling from his father. Although he was a successful student, trained in physics, he left the university before obtaining a degree. For four years, he worked as an apprentice on railroad and hydraulic projects, occasionally collaborating with his father. This experience seems to have gotten him interested in the study of heat and heat engines, and probably reinforced his drive to translate the remotely theoretical into the eminently practical.

He first started publishing papers on physical sciences topics in 1849. He ultimately produced a set of comprehensive engineering textbooks, including, "A Manual of the Steam Engine and Other Prime Movers," 1859, which brought thermodynamics to working engineers. In 1869, Rankine published the first work on the dynamics of rotating shafts, "Centrifugal Whirling of Shafts,"

Engineer, XXVI, April 9, 1869. This became a classical starting point of the new discipline known today as Rotor Dynamics, and ultimately, Rotating Machinery Dynamics.

Rankine was a professor at the University of Glasgow from 1855 until his death, a consultant, and a highly respected authority in a wide range of engineering and scientific topics. He was a bold thinker who freely invented terminology for the disciplines he was interested in. He introduced much of the terminology and notation of thermodynamics, most of which is still in use today. He coined the terms "potential energy" and "critical speed" among others.

It was his boldness and willingness to venture where others hadn't that had a negative effect on rotor dynamics for many years. Rankine's statement in 1865 that, "For every length of shaft there is a speed that cannot be exceeded, and for every speed there is a length of shaft that cannot be exceeded." was the first description associated with limits in machine operation. Though the rule is generally true, what he actually meant was that the first balance resonance was the speed limit for machine operation; this was incorrect. Unfortunately, the influence of this rule lasted over thirty years, even though de Laval showed that machines could run above their "critical" (balance resonance) speed in 1883. ■

#### References:

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